

The Possibility of New Physics in pp Elastic Scattering at LHC

V. Uzhinsky^{1, 2}

Abstract

Modern models of high energy elastic hadron-hadron scattering predict an oscillation character of differential cross sections at the LHC energy of 14 TeV and at a sufficiently high momentum transfer. The Totem collaboration did not see the oscillations at 7 TeV. According to some predictions, the oscillations are weak at 7 TeV in the studied 4-momentum transfer range ($|t| < 2.5 \text{ GeV}^2$). They may be beyond the range of the experiment. But a direct extension of the Totem collaboration data on the pp -scattering at 7 TeV above $|t| \sim 2.5 \text{ GeV}^2$ contradicts previous measurements. Thus the collaboration can discover either the oscillations at large $|t|$ or a change of the differential cross section behavior in the high $|t|$ region ($|t| > 2.5 \text{ GeV}^2$).

For the first time, a collection of several theoretical model predictions of the differential elastic pp -scattering cross sections at the LHC energy 14 TeV [1, 2, 3, 4, 5] was presented in a paper by M.M. Islam et al. [5]. It is shown in Fig. 1 as reproduced from [5]. As seen, all of the models except one by M.M. Islam et al. predict oscillations in the differential cross sections at $|t| > 2 \text{ GeV}^2$. As stated in that paper [5] – "All these models predict visible oscillations as well as much smaller cross sections than ours in the large $|t|$ region. Therefore, precise measurement of elastic $d\sigma/dt$ at large $|t|$ by the TOTEM group will be able to distinguish between our model and the other models and shed light on the dynamics of deep-elastic pp scattering".

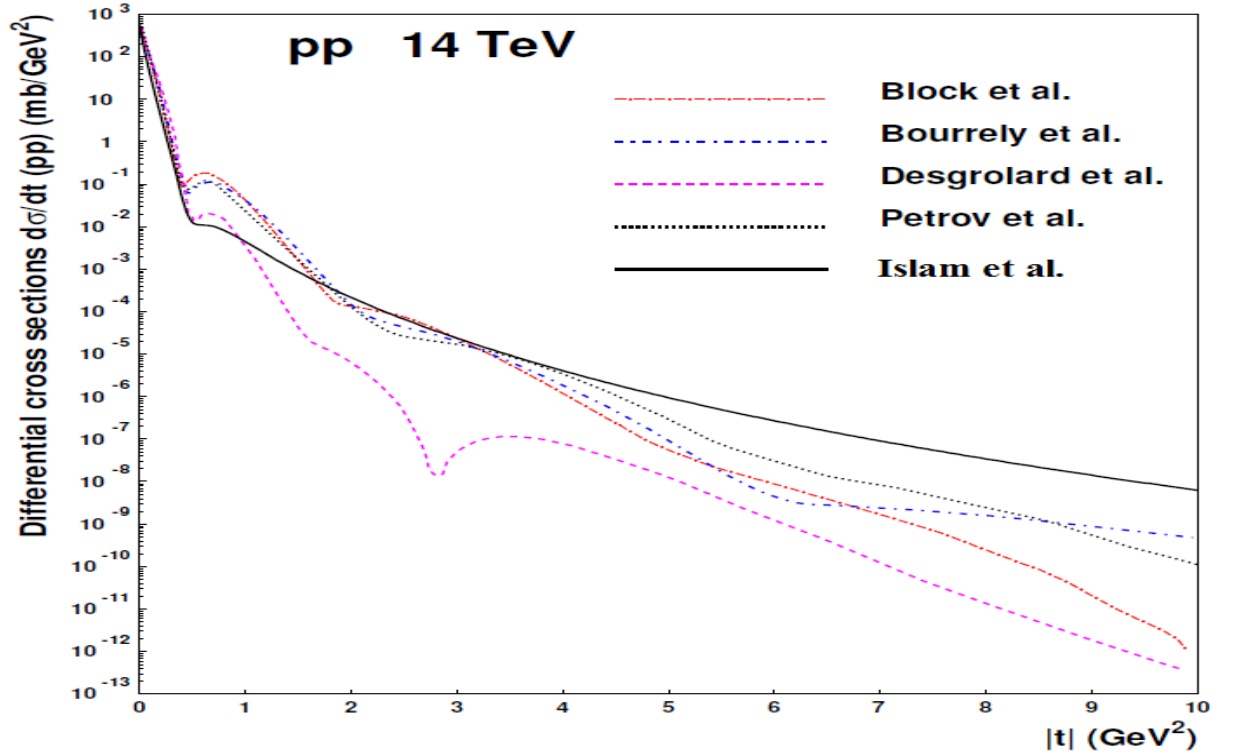


Figure 1: Model predictions for $\sqrt{s} = 14 \text{ TeV}$. The figure is copied from [5].

A few more predictions are presented in [6]. They are not very different from that given in Fig. 1.

The situation for predictions at 7 TeV center-of-mass energy is more complicated. Some of these predictions [2, 7, 8, 9] are shown in Fig. 2, in which the oscillations do not appear clearly if at all. Perhaps with improved calculations, the oscillations will appear.

¹CERN, Geneva, Switzerland

²On leave of LIT, JINR, Dubna, Russia

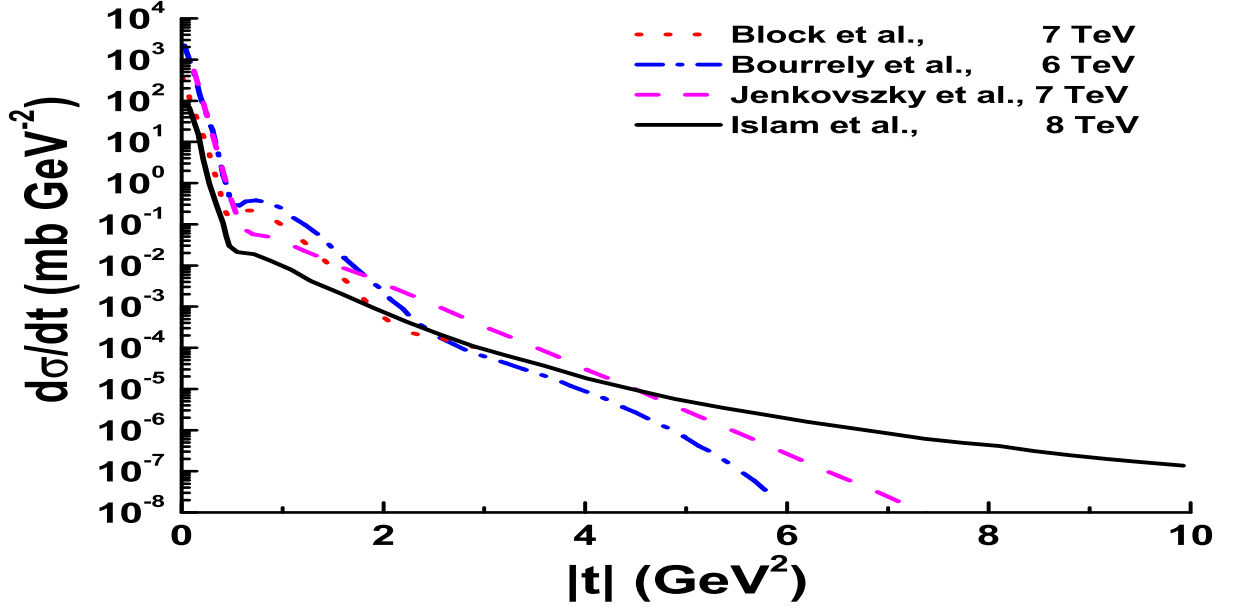


Figure 2: Model predictions for $\sqrt{s} \sim 7$ TeV.

In a paper [10] a description of the Totem collaboration data [11, 12] for elastic pp-scattering at $\sqrt{s} = 7$ TeV and 4-momentum transfer $|t| < 2.5$ GeV² was given. Extension of the calculations above $|t| = 2.5$ GeV² shows the oscillations which are due to the diffraction structure of the soft scattering. In that paper we proposed a unified, systematic treatment of soft elastic scattering data starting from $P_{lab} > 10$ GeV/c. In the description of the high momentum transferred part we followed the approach of papers [13, 14] which does not assume a complicated structure of the hard amplitude.

Recently, a new model of high energy elastic pp-scattering was published [15]. It describes the Totem data and predicts the oscillation also. So, the oscillations are expected in most of the models. At the same time, in the last paper [16] damped oscillations are predicted. Will the oscillations appear in differential elastic scattering?

The existing Totem data presented in Fig. 3 cannot give an answer. As seen, they are ended just in the point where the oscillation can start. Maybe with extended measurements, the oscillations will appear.

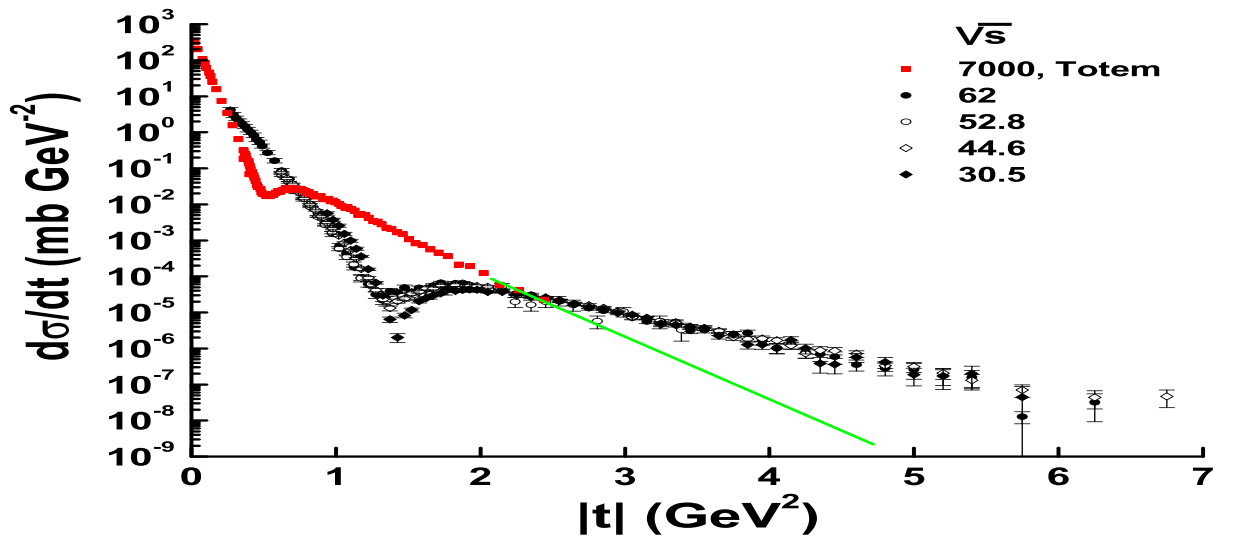


Figure 3: pp elastic scattering data at large momentum transfer. Points are experimental data [11, 12],[17],[18],[19].

There is no doubt that a determination of the most reliable theoretical model is an important task searching for the oscillations. More important, though, is a search for new phenomena, for which a clear signature is predicted.

Previous low energy data on elastic pp scattering are presented in Fig. 3 also. They clearly contradict a direct extrapolation of the Totem data shown by the solid (green) line. We look forward to a significant improvement in data at large $|t|$ in which the Totem collaboration could discover the new phenomenon – a change in the spectra at large $|t|$.

I believe that the Totem collaboration has all possibility to make a new discovery at the LHC – to find the oscillation or the change.

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